

**INDIANA DEPARTMENT OF TRANSPORTATION  
MATERIALS AND TESTS DIVISION**

**WATER-CEMENTITIOUS RATIO  
ITM 403-02T**

**1.0 SCOPE.**

- 1.1 This test method covers the procedure to determine the water-cementitious ratio for a concrete mixture.
- 1.2 The values stated in English units or SI metric units are to be regarded separately as standard, as appropriate for a specification with which this ITM is to be used. Within the text, metric units are shown in parenthesis. The values stated in each system shall be used independently of the other, without combining values in any way.
- 1.3 This ITM may involve hazardous materials, operations and equipment. This ITM does not purport to address all of the safety problems associated with the ITMs use. The ITM user's responsibility is to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

**2.0 REFERENCE.**

- 2.1 **AASHTO Standards.**
  - M 231 Balances Used in the Testing of Materials
  - T 255 Total Moisture Content of Aggregate by Drying
- 2.2 **ITM Standards.**
  - 207 Sampling Stockpiled Aggregates
  - 910 Verifying Balances
- 2.3 **INDOT Manuals.**
  - Inspection and Sampling Procedures for Fine and Coarse Aggregate

**3.0 TERMINOLOGY.**

- 3.1 **Terms and Abbreviations.** Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101 except as follows.
- 3.2 **Cementitious Material.** Portland cement and pozzolans.

**3.3 Free Water.** The water added to the concrete mixture plus the water carried by the aggregates in excess of that held in absorption.

**3.4 Water-Cementitious Ratio.** The ratio between the weight (mass) of free water and the weight (mass) of cementitious material in a concrete mixture.

**3.5 Maximum Particle Size.** The smallest sieve opening through which the entire amount of the aggregate is permitted to pass.

#### **4.0 SIGNIFICANCE AND USE.**

**4.1** This procedure is used to determine the water-cementitious ratio of a representative batch of concrete.

**4.2** The water-cementitious ratio of the representative batch is compared to the maximum allowed water-cementitious ratio to ensure the concrete meets specification.

#### **5.0 APPARATUS.**

**5.1 Balance.** A device used to measure weight (mass) with a capacity of up to 100 lbs (45 kg) and readable to .01 lbs (0.005 kg), as per AASHTO M 231.

##### **5.2 Heat Sources.**

**5.2.3 Electric skillet.** A frying pan heated by electrical conduction from elements within the pan and capable of sustaining at least 215 °F (100 °C).

**5.2.4 Heat lamp.** A lighting device that heats adjacent objects by radiant energy to at least 215 °F (100 °C).

**5.2.5 Stove.** An apparatus that provides heat for warmth or cooking using fuel or electricity as a source of power and capable of sustaining at least 215 °F (100 °C).

**5.2.6 Ventilated Oven.** An enclosed compartment of at least 1.75 ft<sup>3</sup> (.05 m<sup>3</sup>) in which air can circulate through. This compartment is supplied with heat by fuel or electricity and capable of reaching and maintaining 230±9 °F (110±5 °C).

- 5.3 Heat Shield.** A barrier that prevents the heating of a space or an object by absorbing, reflecting or dissipating external heat.
- 5.4 Pan.** A wide, shallow, open vessel made from heat resistant material, the depth of which is less than one-fifth the least lateral dimension.
- 5.5 Spatula.** A flat blade attached to a rigid handle made from heat resistant material and approximately 10 in. (250 mm) long.
- 5.6 Spoon.** A shallow bowl attached to a rigid handle made from heat resistant material and approximately 10 in. (250 mm) long.

## **6.0 PROCEDURE.**

- 6.1** Obtain a representative sample of the coarse (C.A.) and fine aggregate (F.A.). Stockpile sampling will be conducted in accordance with ITM 207. Discharge sampling will be in accordance with INDOT manual entitled "Inspection and Sampling Procedures for Fine and Coarse Aggregates".

When a mechanical diversion or slide chute system does not exist at a truck mix plant, a representative sample may be obtained by charging 5000 lbs (2300 kg) or approximately 3 yd<sup>3</sup> (1.75 m<sup>3</sup>) of aggregate into the weigh hopper. Run the aggregate through the transit mix plant, in lieu of the truck mixer, and use a front end loader to capture all of the weighed material. Roll the aggregate out of the loader bucket into a small pile and sample in accordance with ITM 207, except that further mixing of the stockpile is not recommended.

Place the sample in a non-absorptive sealable container for transport to the field lab.

- 6.2** The minimum sample size required for testing each aggregate size is 11.00 lbs (5.000 kg)
- 6.3** Select a clean and dry pan in which to dry the aggregates. Determine and record the weight (mass) of the clean and dry pan to the nearest 0.01 lbs (0.005 kg).

- 6.4** Place at least the minimum sample size required for testing in the pan. Determine and record the weight (mass) of the pan and the original sample.
- 6.5** Dry the original sample by applying heat to the pan and sample in accordance with AASHTO T 255. The heat source may be an electric skillet, oven, stove or heat lamp. In cases where the aggregate is altered by heat, the drying should be conducted using a ventilated controlled temperature oven. The sample will be considered dry when the sample weight (mass) decreases by less than 0.01 lbs (0.005 kg) over five minutes of heating. Be careful to avoid the loss of any aggregate. Rapid heating may cause some particles to explode. Stir the sample during drying to accelerate drying and avoid localized heating with the spatula or spoon.
- 6.6** Determine and record the weight (mass) of the dry sample and pan to the nearest 0.01 lbs (0.005 kg). Use a heat shield to protect the balance. Tare the heat shield prior to dry sample weight (mass) determination.
- 6.7** Determine the weight (mass) of water in the original sample by subtracting the weight (mass) of the dry sample and pan from the weight (mass) of the original sample and pan.

Water {lb (kg)} = Original & pan {lb (kg)} - Dry sample & pan {lb (kg)}

- 6.8** Determine the weight (mass) of the dry sample by subtracting the weight (mass) of the pan from the weight (mass) of the dry sample and pan.

Dry sample {lb (kg)} = Dry sample & pan {lb (kg)} - Pan {lb (kg)}

- 6.9** Determine the percent moisture content of the original sample by dividing the weight (mass) of the water in the original sample by the weight (mass) of the dry sample and multiplying by 100 percent. Record to the nearest 0.01 percentage point.

Percent moisture=[Water {lb (kg)}/Dry sample {lb (kg)} ]x100%

- 6.10** Determine the percent absorption of the coarse aggregate and fine aggregate from the concrete mix design (CMD) or contact the DMTE.
- 6.11** Obtain a batch ticket representative of the concrete tested.

- 6.12** Determine the weight (mass) of the batched coarse and fine aggregate charged into the concrete mixer as stated on the batch ticket.
- 6.13** Determine the weight (mass) of dry coarse aggregate and dry fine aggregate in the concrete mixture batch by the following formula. Record value to the nearest 1 lb (0.5 kg).

Dry aggregate {lb (kg)} = Batched aggregate / (1.0 + Percent moisture/100)

- 6.14** Determine the weight (mass) of water in the coarse and fine aggregates by subtracting the weight (mass) of the dry aggregate from the weight (mass) of the batched aggregate.

Water carried aggregates {lb (kg)} = Batched aggregate {lb (kg)} - Dry aggregate {lb (kg)}

- 6.15** Determine the weight (mass) of the water absorbed by the coarse aggregate and fine aggregate to the nearest 1 lb (0.5 kg) by multiplying the weight (mass) of dry aggregate by the percent absorption divided by 100 percent.

Water absorbed {lb (kg)} = Dry aggregate {lb (kg)} x Percent absorbed/100 percent

- 6.16** Determine the total weight (mass) of the water in the aggregates by adding the weight (mass) of water in the coarse aggregate with the weight (mass) of the water carried in the fine aggregates.

Total water in aggregates {lb (kg)} = WICA {lb (kg)} + WIFA {lb (kg)}

Where:

WICA = Water in coarse aggregate

WIFA = Water in fine aggregate

- 6.17** Determine the total weight (mass) of the water absorbed by adding the weight (mass) of water absorbed by the coarse aggregate with the weight (mass) of water absorbed by the fine aggregate.

Total water absorb {lb (kg)} = WACA {lb (kg)} + WAFA {lb (kg)}

Where:

WACA = Water absorbed by the coarse aggregate

WAFA = Water absorbed by the fine aggregate

- 6.18** Determine the weight (mass) of all water added to the batch of concrete as stated on the batch ticket to the nearest 1 lb (0.5 kg).

$$WATM \text{ lbs (kg)} = 8.33 \text{ lbs/gal (1kg/l)} \times WATM \text{ gal (l)}$$

Where:

WATM lbs (kg) = Water added to mixture in pounds (kilograms)

- 6.19** Determine the weight (mass) of the total free water in the concrete mixture by adding the weight (mass) of the total water in the aggregates plus the weight (mass) of all the water added to the mixture minus the weight (mass) of total water absorbed.

Truck mix plants may hold back three to five gallons (11 to 19 L) of water to be used by the driver to wash down the funnel and front drum fins during the mixing cycle. If the truck mix plant does not hold back water, the amount of water added to the truck mixer must be determined and used to calculate the water cementitious ratio.

$$\text{Free water \{lb (kg)\}} = \text{TWIA \{lb (kg)\}} + \text{WATM \{lb (kg)\}} - \text{TWA \{lb (kg)\}}$$

Where:

TWIA = Total water in the aggregates

WATM = Water added to mixture

TWA = Total water absorbed

- 6.20** Determine the weight (mass) of Portland cement in the batch of concrete as stated on the batch ticket.
- 6.21** Determine the total weight (mass) of pozzolans in the batch of concrete by summing the weight (mass) of each pozzolan.

$$\text{Total pozzolan\{lb (kg)\}} = \text{Fly ash\{lb (kg)\}} + \text{GGBFS\{lb (kg)\}} + \text{Silica Fume\{lb (kg)\}}$$

Where:

GGBFS = Ground granulated blast furnace slag

- 6.22** Determine the weight (mass) of cementitious material added to the concrete mixture by totaling the weight (mass) of cement and pozzolans shown on the batch ticket.

Cementitious {lb (kg)} = Portland cement {lb (kg)} + Pozzolans {lb (kg)}

- 6.23** Determine the water-cementitious ratio to the nearest 0.001, by dividing the weight (mass) of free water in the concrete mixture by the weight (mass) of cementitious material in the concrete mixture.

Water-cementitious ratio = Free water {lb (kg)} / cementitious {lb (kg)}

## **7.0 Reports.**

- 7.1** Record the water-cementitious ratio.

**Water-Cementitious Ratio Work Sheet**

Date: \_\_\_\_\_

Contract: \_\_\_\_\_

Weight (mass) of cement batch: \_\_\_\_\_

Project: \_\_\_\_\_

Max permitted w/c ratio: \_\_\_\_\_

			Col. 1	Col. 2
Row	Procedure	Method	C.A.	F.A.
A	Weight (mass) original sample & pan, lb (kg)	Weigh		
B	Weight (mass) dry sample & pan, lb (kg)	Weigh		
C	Weight (mass) of water in sample, lb (kg)	A-B		
D	Weight (mass) of pan, lb (kg)	Weigh		
E	Weight (mass) of dry sample, lb (kg)	B-D		
F	Percent moisture (%)	(C/E) 100		
G	Percent absorption (%)	CMD		
H	Weight (mass) wet aggregate in batch, lb (kg)	Batch Ticket		
I	Weight (mass) dry aggregate in batch, lb (kg)	$H/(1.0+F/100)$		
J	Weight (mass) water in aggregate in batch, lb (kg)	H-I		
K	Weight (mass) water absorption in batch, lb (kg)	$I(G/100)$		
L	Total weight (mass) water in aggregate, lb (kg)	J1+J2		
M	Total weight (mass) water absorbed, lb (kg)	K1+K2		
N	Total water added to batch, lb (kg)	Batch Ticket		
O	Total free water in batch, lb (kg)	N+L-M		
P	Weight (mass) Portland cement in batch, lb (kg)	Batch ticket		
Q	Total weight (mass) pozzolans in batch, lb (kg)	Batch ticket		
R	Total weight (mass) cementitious in batch, lb (kg)	P+Q		
S	Water-cementitious ratio	O/R		

**Notel:** Truck mix plants may hold back three to five gallons (11 to 19 L) of water to be used by the driver to wash down the funnel and front drum fins during the mixing cycle. If the truck mix plant does not hold back water, the amount of water added to the truck mixer must be determined and used to calculate the water cementitious ratio.

REMARKS:

Signature: \_\_\_\_\_

Title: \_\_\_\_\_